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THE USE OF INDICATOR SPECIES AS A MEANS OF ASSESSING THE ENVIRONMENTAL CONDITION OF THE WEEKS BAY NATIONAL ESTUARINE RESERVE

KEN R. MARION
University of Alabama at Birmingham
and
JOHN J. DINDO
Dauphin Island Sea Lab

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Department of Biology
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August 12, 1987

National Oceanic and Atmospheric Administration
Office of Ocean and Coastal Resource Management
Management and Budget Group
3300 Whitehaven Street, N.W.
Washington, D.C. 20235

Dear Sirs:

Please find enclosed the final report for Sanctuaries Program Grant # NA86AA-CZ018 by Ken Marion and John Dindo. Thank you for allowing the delay.

Sincerely,

Ken R. Marion

Ken R. Marion
Professor of Biology
University of Alabama at Birmingham
Birmingham, AL 35294
(205) 934-3582
(205) 934-8308 (message)

KRM/flo

Enclosure: photo enclosed in folder

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THE USE OF INDICATOR SPECIES AS A MEANS OF ASSESSING THE ENVIRONMENTAL CONDITION OF THE WEEKS BAY NATIONAL ESTUARINE RESERVE

by

KEN R. MARION
University of Alabama at Birmingham
University Station
Birmingham, Alabama 35294

and

JOHN J. DINDO
Dauphin Island Sea Lab
P.O. BOX 369-370
Dauphin Island, Alabama 36528

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ABSTRACT

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PREFACE

The authors wish to thank the following organizations or individuals: The Dauphin Island Sea Lab, for providing technical support and services; Fish River Marina, for providing boat launch facilities; the UAB Biology Department, for providing vehicle assistance; Mr. Bill Tucker, Alabama Department of Conservation, for encouragement and assistance; Dr. Judy Stout, Dauphin Island Sea Lab, for plant identification; Dr. James Dobie, Auburn University, for assistance in the field; Ms. Freddie Oglesby, for typing the report; and our wives, for their understanding of why we always came home late.

INTRODUCTION

Estuarine and coastal marsh ecosystems of North America are clearly systems under stress. Pollution, dredge-and-fill operations, and coastal real estate development have resulted in the rapid loss of much of our original productive marsh and estuarine acreage (Stout, 1979). These ecosystems are important nursery grounds for many economically-important seafood items, and they contain many organisms unique to brackish water situations. Though it is well known that coastal marshes and estuaries are somewhat resistant to low levels of disturbance, significant or long-term low level perturbations can have severe impacts on the productivity of these ecosystems (Perkins, 1974). Losses of productivity or actual losses of the habitat itself are then reflected in reductions of organisms that are linked to or limited to estuarine and marsh ecosystems (McLusky, 1981).

In particular, the Mobile Bay estuary ecosystem and the surrounding Alabama coastline are facing a growing series of environmental pressures:

1. A wide variety of industrial by-products, urban runoffs, and agricultural pollutants and sediments reach the waters of the Bay. This is largely the result of an average river discharge rate into the Bay of 62,500 cu. ft. per second, the fourth largest in the United States (Loyacano and Busch, 1979). With increasing industrial development, significant alterations of some local ecosystems and further losses of productive marsh habitat are likely.
2. The recent completion of the Tennessee-Tombigbee Waterway may eventually generate new industrial expansion in the surrounding region. Increased barge traffic would likely increase the possibilities of chemical spills.

3. Plans are underway for the enlargement of the Alabama State Docks and deepening of the navigation channel in Mobile Bay. These activities will enhance further development.

4. Potential off-shore dumping grounds for hazardous wastes and fill have been designated (Birmingham News, Apr. 21, 1985), and the transport of chemical and/or hazardous wastes through the Bay for dumping at sea is a distinct possibility.

5. Industrial and commercial expansion is continuing in the Bay area. Numerous chemical-oriented industries have located in the region in recent years. The 1,500-acre Theodore Industrial Park has several new complexes in the planning stages and another industrial park near Coden is being planned. The South Alabama Regional Planning Commission indicates that approximately 4,000 acres of industrial land will be required to satisfy the anticipated industrial requirements for the year 2000 (Ala. Coastal Area Board pub., 1980). Three thousand of these acres will need direct access to the Bay or its tributaries. All of this activity likely means increased levels of detrimental discharges and runoff into Bay waters and the direct and/or indirect loss of many acres of productive marsh/estuarine habitat. Already, it is known that heavy metal concentrations from industrial sources are exceptionally high in Bay sediments (Isphording et al., 1983).

6. Natural gas and petroleum exploration in the Bay and offshore waters is moving toward the production phase. Refinery operations, pipelines, storage facilities and associated constructions are being built or are being planned, all increasing the possibilities of accidents or spills. Incidents have already occurred involving the dumping of toxic drilling mud (Birmingham News, Aug. 15, 1982).

7. Because of the coastal location and attractive environment, the populations of Baldwin and Mobile Counties are rapidly increasing. A 20% increase to a population of nearly one-half million is projected by the year 2000 (Ala. Coastal Area Board pub., 1980), accelerating pressure on the estuarine environment. Further, during the last few years, suburban expansion, dredging, filling, and waterfront development have brought more and more dwellings and condominiums to the edges of the Bay and along the Alabama Gulf Coast, resulting in the direct loss of marsh and coastal habitats.

As part of the Mobile Bay ecosystem, the Weeks Bay National Estuarine Reserve faces not only the problems outlined above, but others of its own, as well:

1. The Fish and Magnolia Rivers, which flow into Weeks Bay, drain thousands of acres of large-scale agricultural operations. Agricultural income accounts for a sizeable portion of the yearly income of Baldwin County (Alabama Coastal Area Board pub., 1980). Sediments and pesticides from these operations are undoubtedly washed into the Fish and Magnolia Rivers during heavy rains.
2. Population expansions immediately north (Daphne, Fairhope) and east of the Reserve are indirectly impacting on the Weeks Bay estuarine environment and its water quality through a variety of processes. Sewage problems, planned outfalls, and septic tanks both above and below the Reserve could have potential detrimental effects (Birmingham News, Apr. 22, 1985). Loss of habitat above and below the Reserve threatens isolation and abnormal population pressures on many vertebrate species in Weeks Bay. In addition, increased human activity for recreation purposes is occurring.

Thus, it is apparent that in the very near future areas of coastal marsh/brackish water habitat and productive estuarine systems will further diminish in the Mobile Bay ecosystem and surrounding Alabama coastline. Stout (1979) noted that 22% of all natural marshes in the Mobile estuary have already been lost to dredging alone. Unique habitats and organisms may be substantially reduced, and a significant decline in the seafood industry of the state could be an indirect result. This industry is essential to the economy of the area. In 1985 alone, the reported harvest of renewable natural resources in the form of commercially-valuable estuarine-dependent fish and invertebrates contributed approximately 300 million dollars to the local economies of Mobile and Baldwin Counties (pers. comm., Ala. Sea Grant Advisory Svc.).

The establishment of estuarine reserves, like Weeks Bay, however, is an important step in the reversal of this trend. It sets aside biologically productive areas for natural processes. Thus, the establishment of such reserves will play a positive role in preservation of habitats ultimately essential to the economically-important seafood industry. However, these reserves represent but a small portion of the total estuarine habitat and, in particular for Weeks Bay, only a small percentage of the Alabama coast. Far more important than the actual biological productivity such sanctuaries actually contribute is a) their preservation of habitat for research on estuarine processes and b) their potential for education of the general public on the importance of estuarine processes and/or organisms. An improved public awareness and education on estuarine systems is critical in reversing the trend of increasing losses of productive coastal or brackish marsh habitat.

In order for the potential two contributions listed above to be maximized, it is important to establish a sound knowledge of the "environmental condition" of the estuarine Reserve. This catch-all term includes two step-wise elements:

first, a characterization of the habitat types and what organisms are present; and second, an assessment of the disturbance level and current ecological problems impacting on the estuary. The two are immeasurably linked, as it is impossible to accurately assess impacts on ecosystems without first characterizing habitat types and animal assemblages, as different ecological communities respond quite differently to various impacts. A working knowledge of the "environmental condition" of the Reserve can then be used in the future for an assessment of potential long-term changes due to disturbance, thereby: 1) suggesting possible directions for mitigation; 2) pinpointing areas for future research; and 3) providing background information important in designing effective education programs to enhance public awareness of estuaries.

Specifically, a sufficient knowledge of what organisms are in the Weeks Bay Reserve and surrounding areas, their abundances, and their distribution within the Reserve habitats is generally unavailable. Likewise, recent disturbance levels have not been assessed. Indeed, the abundance and distribution of many vertebrate species inhabiting the coastal marsh/lowland swamp habitats of Alabama is poorly known (Mount, 1986). It is the most poorly investigated area of the state and, as a result, has many biological question marks in the areas of geographic distribution, habitat association, and abundance. Specific examples of our lack of natural history knowledge of coastal marsh, brackish, swamp, or lowland habitats include numerous distribution and abundance questions for several species of rodents, amphibians, and reptiles (Mount, 1986). The reasons for this likely center around the physical difficulty of working such habitats. The Weeks Bay Reserve includes those habitats which have not been adequately assessed or investigated. Covering 3,027 acres of water and shoreline, the Reserve and surrounding environs includes a number of specific habitats: coastal plain rivers, marsh, marsh edge, tidal creeks, lowland hardwood forest, mixed lowland

forest, pine-oak mixture, sand beach, and pitcher plant bog (Fig. 1). Dominant plants include: Black Needlerush (Juncus romerianus), Cordgrass (Spartina cynosuroides; S. patens), Gum (Nyssa sp.), Red Maple (Acer rubrum), Sweet Bay (Magnolia virginianum), Southern Magnolia (Magnolia grandiflora), Wax Myrtle (Myrica cerifera), Laurel Oak (Quercus laurifolia), Water Oak (Quercus nigra), Pond Cypress (Taxodium distichum), Longleaf Pine (Pinus palustris), Slash Pine (Pinus elliotti), and Royal Fern (Osmunda regalis). Water depths are generally shallow (<1.5 m), and large stumps line the shallows. These are remnants of large cypress trees which were cut during the Eighteenth and Nineteenth Centuries.

One time-honored approach used both to accurately characterize specific habitat types and to assess potential impacts and environmental degradation is to evaluate the population status and distribution of indicator species or indicator groups (Warren, 1971). Such organisms are those who have quite specific habitat requirements (nesting, feeding, etc.) and who respond negatively to a variety of environmental perturbations due to habitat loss, food reduction, physical and chemical changes, etc. These events are usually reflected in elimination, population reduction, or restriction of habitat.

The major objective of this project was to evaluate the "environmental condition" of the marsh/estuarine habitat of the Weeks Bay National Estuarine Reserve. This was approached by characterizing the specific major habitat type and its animal associations, primarily by natural history survey, and by assessing the occurrence and abundance of pre-selected indicator species or groups of organisms. Such information can then be used to: 1) determine the current ecological impact on the Reserve and to project potential long-term changes in the ecological status of the area; 2) clarify the directions for future research; 3) provide information on the status of potential threatened or endangered species in the area; and 4) effectively design future educational

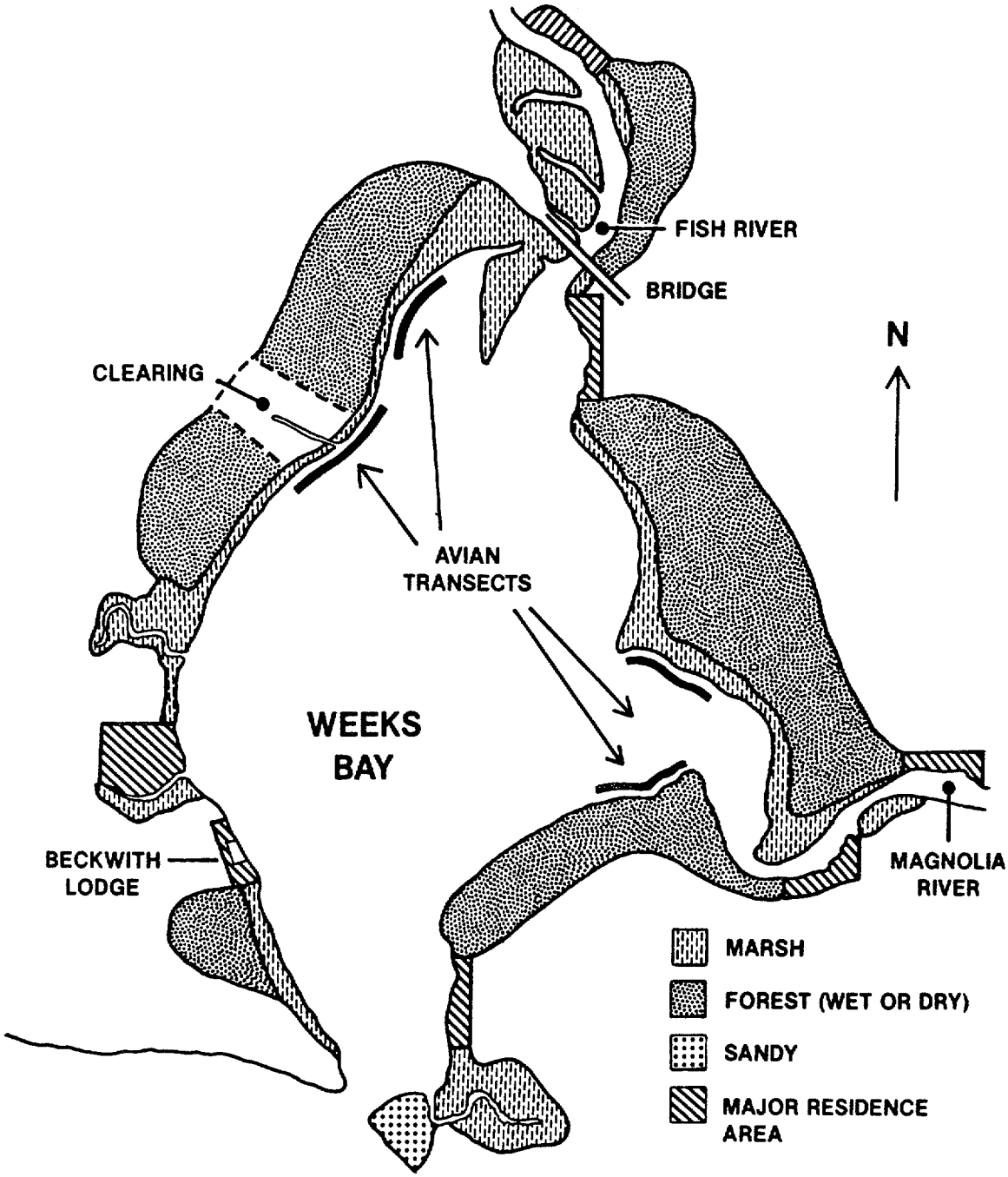

Figure 1. General Map of the Weeks Bay National Estuarine Reserve. The Swift Tract on Mobile Bay, southeast of the Bay proper, is not shown. The four 300-meter shoreline transects, established primarily for bird quantification surveys, are shown.

efforts to enhance public awareness of the importance of this and other estuaries.

The indicator species or groups primarily targeted for initial and most intensive investigation in this study were the Gulf Salt Marsh Water Snake (Nerodia faciata clarki), water snakes in general, the Mississippi Diamondback Terrapin (Malaclemys terrapin pileata), the herons or long-legged wading birds (Order Ciconiiformes), and other shorebirds. The types and abundances of water snakes, herons, and shorebirds strongly characterize specific habitat types and animal associations, and can be useful in assessing ecological impacts (Smith, 1974). Wading birds, in particular, have been used in a number of studies as indicators of marsh habitat changes (Custer and Osborn, 1977; Henry et al., 1983). As a terminal link in food chains, they are known to be sensitive to several kinds of environmental changes. Studies have shown that populations of wading birds are affected by alterations in their feeding habitat and breeding locale, both often as a result of increased urbanization and agricultural development (Custer and Osborn, 1977; Kushland and White, 1977). Other studies have shown that variations in numbers of wading birds are directly related to food abundance (Owen, 1960). In addition, wading birds are well known to be sensitive to the amounts of pesticides, heavy metals, and other organic pollutants in the environment (Ohlendorf et al., 1974; Henry et al., 1983). Thus, these animals directly reflect habitat and ecosystem alterations. The Gulf Salt Marsh Water Snake and the Diamondback Terrapin were selected because of their specific habitat requirements, their general interest due to recent declines (Mount, 1986), and their future projections as potential threatened or endangered species. Both species are restricted to marsh habitats with frequent medium to high salinities. When it became evident that these species were not in abundance in Weeks Bay, other potential indicator species more characteristic of brackish habitats were investigated.

METHODS

The Weeks Bay National Estuarine Reserve was investigated on 22 days over the period of the study. The dates were: 4/29/86, 5/1, 5/27, 6/4, 6/5, 6/24, 7/14, 7/15, 8/23, 8/24, 9/9, 10/9, 10/17, 10/18, 11/11, 11/12, 12/2, 12/16, 12/17, 1/13/87, 2/13, and 3/20. During each trip, weather conditions, air temperature, water temperature, and tide level were noted. Salinities were taken by refractometer in at least two of the following locations: Fish River Bridge, the inlet mouth, Transect 1, and Transect 4 (Fig. 1).

In order to assess the "environmental condition" of the Weeks Bay Reserve, the following approaches were taken: 1) assessing the population status of two reptile species which are closely linked to relatively undisturbed marsh/estuarine ecosystems; 2) determining the avian abundance and diversity; and 3) performing a natural history survey of all non-fish vertebrates.

The avian fauna was quantitatively evaluated by time-distance survey methodology. Time-distance counts have been routinely employed in a large number of bird studies, and the technique is recognized as standard methodology for quantification in avian studies (Giles, 1969; Conner and Dickson, 1980). In this method, a specific length of ecotonal habitat is surveyed by binoculars for a set period of time. All birds seen are then identified and counted. Within Weeks Bay, four shoreline transects, each approximately 300 meters in length, were established in areas that represented the ecological diversity of shoreline habitats present in the Bay--ranging from regions of extensive Juncus/Spartina marsh to wooded shoreline with no aquatic vegetated edge to wooded shoreline with aquatic vegetated edges (Fig. 1). Each transect was observed from a boat for twenty minutes during each survey. The numbers of each species sighted were recorded. Calls heard during this period that were identifiable to species were also noted. Quantitative avian surveys were

conducted on 14 separate days, encompassing every month and season of the year. A total of 1120 minutes were spent in quantitative survey, with 980 minutes of these occurring with two observers for a total of 2100 man-minutes of quantitative observation.

Comparative time-distance surveys were also performed six times during the year (encompassing all seasons) at two 300-meter transects established near the mouth of Fowl River in Mobile County. This area is undisturbed coastal salt marsh. Woodland regions, however, are surveyable from portions of these transects. These surveys were performed to compare the Weeks Bay avian fauna to that of a true coastal salt marsh.

Gulf Salt Marsh Water Snakes (Nerodia fasciata clarki) were assessed quantitatively by placing nineteen 0.7 x 1.0 m plywood boards to serve as shade habitats in two of the 300-meter shoreline transects established for avian time-distance surveys. These areas were judged to contain the most favorable habitat (in terms of Juncus/Spartina and other shoreline cover) for Marsh Snakes, based on the authors' extensive experiences with this species in other areas of coastal Alabama. The boards were spaced approximately every 30 meters and placed just behind the matted Juncus/Spartina which accumulates at the high tidal wash zone. Each board was marked for easy spotting by attaching a rope to the board and connecting it to a red fluoresecnt styrofoam marker. The use of shade boards is a common methodology for collecting snakes (Mount, 1975). Shade is limited in marsh situations, and Gulf Salt Marsh Water Snakes are known to spend many daylight hours underneath whatever shade they can find in the marsh. The shade boards were placed in location on 5/1/86 and checked on nine subsequent trips. Due to heavy vegetation growth, not all boards could be located for checking on every occasion. A total of 125 boards were checked during the entire period.

In addition to the inspection of shade boards, Marsh Snakes were looked for by wading water edges along the established transects on a number of occasions. All debris was also overturned during any terrestrial activities, and shorelines were intensively investigated by binoculars during the avian time-distance surveys.

The population status of Mississippi Diamondback Terrapins (Malaclemys terrapin pileata) was monitored quantitatively by trapping procedures and by timed wading along marsh shoreline areas. Nine standard turtle funnel traps (1.2 m long x 0.3 m wide x 0.5 m tall) were constructed out of galvanized chicken wire according to the design of Iverson (1979). Five traps were made with funnel openings at each end of 18 cm wide and 6.5 cm tall to accomodate larger turtles. Four traps were designed with funnel openings of 13 x 5 cm. These would be more likely to retain smaller individuals. Similarly designed traps have captured Terrapins in other studies (Carl Ernst, pers. comm.; Marion's previous experience). A marker float was attached by rope to each trap for easy location. Traps were normally baited with commercially-purchased sardines (can with holes punched in it), but on occasion freshly-killed menhaden, blue crabs, and crushed clams were tried. Traps were placed in likely locations (tidal creeks, marsh areas, etc.) at scattered areas in the Reserve. Over the course of the research period, most general locations in the Reserve were trapped. Traps were placed in 0.3 - 1.2 m of water near the shore. Those in shallower locations often were placed to have portions of the cage out of water during low tide periods to prevent possible drowning of captured turtles. From 5-9 traps were set on 12 different occasions, encompassing all periods but December and January, when Diamondback Terrapins are normally buried in the mud on the bottom or inactive and not feeding (Ernst and Barbour, 1972). On eight occasions, traps were placed out in the morning

and picked up in late afternoon, but on four occasions, they were left out overnight and checked the next day.

Two 300-meter marsh shoreline transects were established in likely habitat for Terrapins and were waded on several occasions throughout the study. Turtles were looked for in the flooded, shallow vegetated areas. In addition, several other efforts were made to locate Diamondback Terrapins. These included: 1) binocular inspection of exposed sandy shoreline for basking individuals; 2) binocular inspection of shallow areas for turtle heads at the surface during the avian time-distance surveys conducted from a boat; 3) observation of tidal creeks draining large marsh areas located near the mouth of Weeks Bay during extensive boat travel; 4) interviews with fishermen who have historical knowledge of the fauna of Weeks Bay; and 5) on-site inspection of the Reserve by a recognized turtle expert.

Dr. James Dobie, Professor of Zoology at Auburn University, and a recognized authority on turtle natural history and biology, was brought to Weeks Bay on October 17 and 18, 1986, for inspection of habitat potential for Diamondback Terrapins. During this time, three hoop nets (3 m long x 1 m high) with 30 m wings were employed overnight for Terrapins and the Alabama Red-Bellied Turtle (Pseudemys alabamensis).

General surveys of all non-fish vertebrates were conducted at Weeks Bay during the course of all trips. Observations also extended 1-2 km up the Fish and Magnolia Rivers and included the Swift tract on Mobile Bay. Species present by sight, call, or sign (feces, tracks, nests, etc.), their numbers or abundance, their seasonal occurrence, and their distribution within the various habitat types within the Reserve and surrounding areas were noted. These data were used: 1) to further characterize the environmental status or "condition" of Weeks Bay; 2) to document what fauna are present in the Reserve for potential future studies; and 3) to start an initial natural history data base

for an awarded grant designed to prepare natural history educational materials on animal occurrence and abundance in the Reserve. Such educational materials should enhance public awarenesss of the role and importance of estuaries and marsh ecosystems.

General surveys of birds were conducted by sight, often using binoculars. All habitats within Weeks Bay were routinely surveyed. Amphibians and reptiles were surveyed basically by walking areas of shoreline and terrestrial habitats and turning over logs and debris. Calls were noted. Aquatic turtles in the Fish River were identified by sight while basking. Attempts to capture turtles included the placement of two basking traps under logs known to be used for basking. These traps were constructed out of plastic "hula hoops" with a fine seine net sewed together and attached to the floating hoop. These traps are designed to confine the turtle in the floating net when it drops from the log when approached. The traps were employed on several occasions, but yielded no turtles.

Mammals were surveyed by sight, by noting "sign" (feces, tracks, marks, nests, etc.), and by trapping. On five occasions, Sherman live traps and snap traps were placed at strategic locations in drier, more upland areas of the Reserve to sample rodent populations. From 10-18 traps were baited with peanut butter and/or rolled oats, left overnight, and checked the following morning. A total of 960 trap hours were accumulated.

RESULTS

Gulf Salt Marsh Snakes

No Gulf Salt Marsh Water Snakes (Nerodia fasciata clarki) were collected or sighted in Weeks Bay during the period of the study, despite intensive effort. A total of 125 checks of individual shade boards (placed along two transects on 5/1/86) were made during nine trips. Marsh edges were waded for visual sightings on eleven different occasions for a total of 30.5 man wading-hours. In addition, on two trips (7/14 and 8/23), night surveys along the marsh and shoreline areas were made by Q-beam lights from a boat for a total of six hours. Finally, numerous hours were spent in close proximity to the shoreline during the avian time-distance surveys and in boat travel up several tidal creeks. All failed to produce Marsh Snakes.

Six water snakes of other species or forms, however, were sighted and/or captured during the wading efforts. Five were Banded Water Snakes (Nerodia fasciata fasciata), one of which was captured and preserved, and one was a large Cottonmouth (Agkistrodon piscivorus). Two additional Cottonmouths were observed during other activities. The shed skin of a Yellow-Bellied Water Snake (Nerodia erythrogaster flavigaster) was also found.

Inspection of the one captured specimen revealed no significant variations from the normal variety of color patterns of the Banded Water Snake. Visual sightings of the four other water snakes also revealed no evidence of intergradation between the Salt Marsh Snake and the Banded Water Snake, as all appeared to have normal fasciata fasciata patterning.

Mississippi Diamondback Terrapin

No Mississippi Diamondback Terrapins (Malaclemys terrapin pileata) were captured or sighted by us during the course of study, despite intensive trapping and visual sighting efforts. Traps were employed on 12 occasions,

four of them overnight, for a total of 914 trap hours. Marsh edges were waded for visual sightings on eleven different occasions for a total of 30.5 man wading-hours. In addition, two night surveys of shallow water and shoreline habitat were conducted by boat with Q-beam lights for a total of six hours. Finally, other, less quantitative efforts were also made. Numerous hours were spent traversing by boat the tidal creeks draining the marsh areas near the mouth of Weeks Bay; areas of exposed sandy shoreline were inspected by binoculars on several occasions for basking individuals; and shallow water areas in the transects were examined by binoculars for turtle heads at the surface during the avian time-distance surveys.

A one-time special trapping effort was made during a trip to Weeks Bay by Dr. James Dobie, Auburn University, on 10/17-10/18/86. A large hoop net (3 m long x 1 m high) with a 30 m wing was stretched across the tidal creek draining the south marsh near the mouth of Weeks Bay. The placement of the net totally closed off the creek, and the net was left overnight to cover more than a complete tidal cycle. Numerous fish were captured, but no turtles.

The only Diamondback Terrapin reported to us during the course of our study was captured by Steve Masters at Beckwith Lodge on 3/27/86. The specimen, a large female, had the following measurements: carapace length = 219 mm; carapace width = 150 mm; plastron length = 199 mm; weight = 1637 g. The specimen was released.

Avian Surveys

Avian time-distance surveys were conducted on the four established transects (Fig. 1) on 14 days, encompassing every month and season of the year. A total of 1120 minutes were spent in quantitative survey, with 980 minutes of these occurring with two observers for a total of 2100 man-minutes of time-distance observations.

The results are presented on a seasonal basis in Table 1. Fifty-seven species were identified by sight plus 11 others confirmed by call for a total of 68 species. Two additional species were questionable by call. A total of 745 birds were observed. The results for bird species identified in the two established transects at the salt marshes of Fowl River, Mobile County, are shown in Table 2. Thirty-two species were identified by sight and four others by call during six trips over the year (total of 240 minutes). A total of 304 birds were observed. Observations on the general types of birds seen at Weeks Bay, their seasonality of occurrence, and a comparison to the Fowl River marshes are made in the Discussion.

Vertebrate Surveys

Listings of non-fish vertebrates observed in the course of all activities at Weeks Bay and surrounding areas are presented in Tables 3, 4, and 5. Thirty species of reptiles and amphibians have been identified (26 by sight or capture and four by sign or call); three others are probable. Thirteen mammals have been identified (ten by sight and three by sign). A total of 93 species of birds have been recorded (82 by sight and 11 by call); four others were probable by sight or call. Comments on the general survey of vertebrates are reserved for the Discussion.

DISCUSSION

When viewed in total, the results demonstrate that the overall habitat of the Weeks Bay Reserve can be characterized by its animal associates as a brackish water estuary with strong freshwater influx, bordered by a mixed pine/hardwood lowland forest. Several specific forest types are included. The types, distributions, and abundances of the non-fish vertebrates observed and quantified clearly indicate that saltwater influence is not the dominant,

overriding environmental factor in this particular estuary. This is additionally supported by monthly salinity recordings and plant species observations. The results also show no evidence of any major recent detrimental environmental impact on this estuary, other than minor influences by man. Most of the animal types and population levels approximate what would be nominally expected from the particular habitat type(s) characterized, and are more reflective of responses to natural environmental factors, rather than pollution or severe habitat alteration. These conclusions will be supported by discussing the results obtained in the several activities undertaken.

Survey of Gulf Salt Marsh Water Snake and Diamondback Terrapin

The results indicate that the Gulf Salt Marsh Water Snake is likely not present in the Weeks Bay Reserve. The most likely habitats (such as the marsh on the southern side of the inlet mouth), have been extensively searched. Though one cannot rule out the occurrence of a stray individual, it is clear that there is no population of any consequence, and that they are likely absent. Similarly, a permanent breeding population of Mississippi Diamondback Terrapins is not found in Weeks Bay. Isolated wanderers or incidental individuals occur in Weeks Bay, as they do sporadically up to the Mobile causeway area. The one individual found during the period of this study was likely a nomad responding to spring movements.

Where populations of either animals at even low levels are present in Mobile Bay, the authors have historically been able to spot or find these species with much less comparable effort and using the same methods employed in this study. Individuals of both specimens have been found on numerous occasions at Dauphin Island, Little Dauphin Island, Grand Bay, lower Fowl River, Cat Island, and Point Aux Pins. For example, in one day at Point Aux Pins during 1977, the senior author caught four Terrapins and saw six others.

Eight Salt Marsh Snakes were observed or captured in the same area during one day in 1979. Three Marsh Snakes were caught during a one-hour survey at Dauphin Island during 1986. Even at sites where Marsh Snake populations are low or casual, such as Cat Island, snakes or their shed skins have been sighted on several occasions while not looking for snakes. Comparable efforts as made in this study in the Dauphin Island area have yielded a number of Terrapins. Finally, the only previous trapping efforts for Terrapins made by the senior author (1975) yielded two specimens from Point Aux Pins, with just six traps set for approximately 45 trap hours. In addition, Marion observed dead Terrapins in crab traps at Dauphin Island during 1982. Thus, the efforts expended in this study should have yielded specimens or sightings if other than incidental individuals occur.

Such findings might indicate that populations of both species could have historically been present or more numerous in Weeks Bay, and have declined or been eliminated due to recent man-induced activities or environmental alteration. However, the natural history data and other evidence we have gathered strongly implicates that the major reason for the lack of these two species in Weeks Bay is natural and not man-induced. It is instead due directly or indirectly to low salinities.

Salinity readings were taken at several locations in the estuary during each trip. Maximum and minimum values appear in Table 6. Salinities were generally low in winter and spring, and recordings of zero were made during March, 1987. Overall, these salinity recordings were made during one of the driest years on record. Ernst and Barbour (1972) indicate that Diamondback Terrapins prefer reasonably high salinity levels (average >15ppt) and are often associated with oysters and other mollusks in estuaries and tidal creeks (Carl Ernst, pers. comm.). We have found no oysters in Weeks Bay. Dunson (1970) captured Diamondback Terrapins at salinities ranging from 12-32 ppt. Mount

(1975) states that Salt Marsh Snakes also require marshes with a strong saltwater influence. Substantiating this, Dunson (1980) captured Marsh Snakes in Florida at salinities ranging from 23-31 ppt and Conant and Lazell (1973) captured specimens in North Carolina in habitats with a mean salinity of 21 ppt. Dunson (1980) further demonstrated that Salt Marsh Snakes tolerated 100% sea water (35 ppt) for months in captivity, but fared poorly in freshwater. The salinity values we measured at Weeks Bay were apparently less than other locations where both the Terrapin and Salt Marsh Snake occur, and in wetter years, they would likely be lower.

Other evidence that salinity levels are directly or indirectly restricting the occurrence of these two species in Weeks Bay is provided by animal associations, plant associations, historical information, and direct observations by an experienced turtle biologist. Certain animals characteristic of true salt marsh situations were absent or uncommon in our surveys. The discussion of animal associations is referred to later.

Plant associations found in Weeks Bay also indicate the frequent lack of high salinity conditions. Stout (1979), using plant types, has classified the marshes of Weeks Bay as Brackish Marsh Type I, and not as true salt marsh. Spartina cynosuroides replaces Spartina alterniflora, a true salt marsh species. S. alterniflora is uncommon or absent in Weeks Bay (Stout, pers. comm.) Juncus roemerianus, a species highly tolerant to variable conditions, and Spartina patens are also present in abundance. In addition, cypress stumps cut many years ago are present along much of the shoreline.

Interviews with individuals who have lived and fished on Weeks Bay for many years also provided evidence that environmental conditions have likely not been historically favorable for Marsh Snakes or Diamondback Terrapins. Conversations with a number of people indicated that these animals were unfamiliar to them or uncommon in Weeks Bay. For example, Alton McClintock, a

fisherman who has worked Weeks Bay for forty years, remembers only two Terrapins that he caught in nets. He remarked that he had not caught one in years and that they were never common. He did note, however, that crabbing and netting had increased tremendously in Weeks Bay in recent years. Ken Reagan, operator of Fish River Marina for many years, was familiar with the species, but had not seen one in Weeks Bay.

Finally, direct observations by Dr. James Dobie, Auburn University, confirmed that habitat conditions for Diamondback Terrapins were not ideal in Weeks Bay, at least partially as a result of the salinity regimes. Dr. Dobie, a nationally-recognized turtle expert familiar with the fauna of Mobile Bay, was brought to Weeks Bay expressly for the purpose of his evaluation of the Bay as habitat for the Diamondback Terrapin and the Alabama Red-Bellied Turtle. No Terrapins were seen, despite a trapping attempt and many hours of surveying the most likely habitats in Weeks Bay. Dr. Dobie was also of the opinion that only straggler Terrapins are likely in Weeks Bay and that permanent populations would be miniminal or non-existent. He thought that the habitat was not ideal for three major reasons: 1) salinity regimes are often not sufficient; 2) the tidal creeks draining the marsh are not deep enough; and 3) there are few mollusks in the tidal creeks.

Because the Salt Marsh Snake and Diamondback Terrapin are essentially absent from the brackish-influenced habitats present in Weeks Bay, other closely related organisms more common in these habitats may well serve as indicators of present or past disturbances. Other water snakes and other turtle species are present in Weeks Bay and the rivers that feed it and were, therefore, considered. The Banded Water Snake, the Cottonmouth, and the Yellow-Bellied Water Snake were observed by us. [Note: Mount (1975) observed intergrades of the Salt Marsh Snake (N. fasciata clarki) and Banded Water Snake (N. fasciata fasciata) in the Florida panhandle but has not observed any

intergradation in Alabama. The Banded Water Snakes we saw or captured also had no obvious intergradation characteristics.] Several species of turtles were also observed, but never in Weeks Bay proper. They were always confined to the entrance of the Fish River and upstream areas in both the Magnolia and Fish Rivers.

It was difficult to use any of these species as environmental indicators because of poor quantification and lack of structural habitat requirements. Though comparable data are unavailable in the literature, it is the senior author's opinion from searching comparable freshwater habitats that water snake populations in Weeks Bay are low (only six for 30.5 man wading-hours, plus numerous boat observation hours). In general, Weeks Bay proper is reasonably sterile in water snakes and aquatic turtles. One might be tempted to conclude that the lack of turtles and few snakes of any type observed in the Bay could be the result of an environmental or man-made disturbance. However, brackish water areas as a rule are low in numbers of aquatic-oriented snakes and turtles (Ashton and Ashton, 1981; Ashton and Ashton, 1985). Further, physical structures (basking logs, stumps, etc.) are reasonably important requirements for snakes and turtles, in general. Weeks Bay is nearly devoid of these structures over much of its shoreline area. In addition, the general lack of submerged aquatic vegetation in the estuary would be a further deterrent to most turtle species, especially those who use such vegetation as a food source, as does the River Cooter (Chrysemys concinna). Thus, these animals can only further characterize the specific habitat conditions and are not useful for assessing any impacts. Organisms from other vertebrate groups would provide a better insight.

Avian Surveys

A wide variety of both species and "morphological types" were observed in the avian surveys (Table 1). In addition, a definite seasonal trend was noted. Ducks, grebes, cormorants, and coots were definite cool-weather associates and were not observed on the transects during the summer months.

Several observations are noteworthy from the quantitative surveys:

1) Marsh ducks and other waterfowl that feed on or in submerged vegetation were conspicuously absent. This apparently reflects the lack of submerged vegetation.
2) For the size of the area surveyed, the number of large wading birds (herons and egrets) was quite normal, based on qualitative observations by the authors in other brackish and freshwater habitats.
3) Small wading birds are almost totally absent from Weeks Bay. Exposed mudflats were never observed and edges along the shoreline are dominated by emergent vegetation in most areas.
4) The species observed in the forest/marsh ecotone along the transect are reflective of a normal diversity and abundance of birds likely to be associated with a mixed pine/hardwood lowland forest (Imhof, 1976).

The quantitative observations on birds serve again to characterize the shoreline habitat as a brackish water marsh bordered by a mixed pine/hardwood lowland forest. Birds associated with a marsh/woodland ecotone more strongly influenced by salt water were absent from Weeks Bay or reduced in number. The marshes surveyed at lower Fowl River (Table 2) are closer to salt intrusion, more tidally influenced, and dominated by Spartina alterniflora. Louisiana (Tri-Colored) Herons, nearly totally restricted to the salt marshes or immediate coastline (Imhof, 1976), were observed at lower Fowl River, but not at Weeks Bay. Black Skimmers were also observed at Fowl River, but not at Weeks Bay. In addition, per minute of observation, gulls, terns, and small

wading birds were more abundant at Fowl River. Using the same comparisons, herons and egrets were also more common at Fowl River, but this comparison is less revealing, because of the close proximity of Fowl River to the heronry on nearby Cat Island.

Almost twice the number of birds observed per minute of observation were recorded for lower Fowl River as for Weeks Bay (1.27 vs 0.67 birds/min.). It is the authors' opinion that this reflects the nature of the habitat differences between the two sites, rather than significant man-made impacts on the Weeks Bay estuary. The difference largely reflects the increased numbers of herons, gulls, and terns at Fowl River, with other bird species reasonably similar between the two areas, considering the differentials in effort. Salt marshes, tidal creeks, and salt coastlines are known to be among the most productive avian feeding areas (McLusky, 1981). Brackish water areas, on the other hand, usually show some falloff in avian abundance (Remane and Schleiper, 1971). Few comparisons can be made to other appropriate brackish water areas, as little quantitative data in the form of time-distance surveys are available for these habitats in the literature and methodologies differ considerably between surveys. Holliman (1984), however, has performed similar surveys in other areas of Mobile Bay and the Mobile Delta that are brackish to varying degrees and have wooded shorelines. The abundance of birds in Weeks Bay is not out of line with these figures(Holliman, 1984). The number of species observed in Weeks Bay was somewhat low in comparison, but is reasonable considering that most of the surveys were conducted in the middle of the day. Our species list and abundances per time spent also are comparable to counts conducted along the Alabama coastal zone for several years (American Birds, 1976-80; Alabama Birdlife, Vol. 21:2-9, 1973) and to findings in bottomland hardwood forests in Louisisna (Dickson, 1978).

The lack of marsh ducks associated with submerged vegetation does suggest the possibility of some deterioration in water quality and/or clarity. No conclusions can be made without historical knowledge. However, one Bay "veteran" could never recall significant submerged vegetation.

Vertebrate Surveys

The vertebrate surveys (Tables 3, 4, 5) conducted during the course of all activities further serve to characterize the habitat regimes and animal associations found in Weeks Bay. Viewing the reptiles, amphibians, mammals, and birds observed, it is evident that the marsh habitat is of a brackish nature and is not "true" salt marsh. Certain species in each class associated with each other in salt marsh situations are not present. Instead, other associations occur. The types of animals found in the terrestrial habitats are typical of those found throughout mixed pine/hardwood lowland habitats and Bay Forests along the northern Gulf Coast.

A wide variety of birds (Table 5) have been sighted. This reflects the mixture of various habitat types at Weeks Bay. Several trends were observed. Seasonality was evident, with grebes, cormorants, ducks (generally mergansers), coots, and some of the sparrows being obvious winter associates. Diversity of birds was greater in spring and winter, as migrants passed through and others spent the winter along the Gulf Coast. A wide variety of herons and egrets were observed and were quite common. The Louisiana (Tricolor) Heron, associated with salt-influenced environments (Imhof, 1976), was conspicuously absent. Ducks were poor in diversity and were generally divers, such as the mergansers. Clapper Rails do occur, but do not appear to be as abundant as in saltier marshes on the western side of Mobile Bay. The King Rail, more of a brackish or freshwater species (Imhof, 1976), was heard on one occasion. Shorebirds are almost non-existent, due to the lack of wading flats. Terns and

gulls are abundant. Passerines, piciformes, and other birds typically associated with mixed pine/hardwood lowland forests and Bay Forests along the northern Gulf Coast (Imhof, 1976) were also abundant in Weeks Bay. Since large dead trees are relatively common in these habitats, woodpeckers are abundant. Other common species were Fish Crow, Carolina Wren, Mockingbird, Yellow-Rumped Warbler, Pine Warbler, Red-Wing Blackbird, Grackle, Blue Jay, and Cardinal.

The amphibians and reptiles found during the study (Table 3) are typical of wet lowland regions adjacent to higher, drier regions along the Gulf Coast (Mount, 1975). Since habitats within the Reserve range from sandy and dry to moist and swampy, the list of amphibians and reptiles reflects this diversity. The abundance of skinks, anoles, and small frog species is indicative of low, moist woodlands. Two reptiles, the Diamondback Terrapin and the Gulf Salt Marsh Water Snake, clearly associated with salt marsh situations, are rare or absent. Those species found which are closely linked to aquatic situations are associated with fresh or brackish water conditions. Two young Atlantic Loggerhead Turtles were reportedly taken by trawl near the mouth of Weeks Bay, but this could not be confirmed. Several amphibians and reptiles are undoubtedly found in the Reserve and adjacent areas that do not appear on this list.

The list of mammals (Table 4) that we have observed is undoubtedly deficient, primarily because of their nocturnal nature. Raccoons and Swamp Rabbits are the dominant mammals. Rodents, such as squirrels and mice, are not numerous, typical of most low, moist habitats. Bottlenose Dolphins occasionally find their way into Weeks Bay, but we have seen no evidence of nutria, common residents of salt marshes along the northern Gulf Coast. These animals may be found in brackish situations, but reach their peak abundance under reasonably strong saltwater influence.

The vertebrates of all classes found reflect the diversity of habitat types in and adjacent to Weeks Bay. Areas ranging from "blackwater" swamps to fields to low, wet forests to dry, sandy dunes to brackish marsh to river systems can be found. Though many of these microhabitats alone are often reasonably poor in species diversity and abundance, the mixture of small areas of several habitats provides a reasonably rich mixture. If the river areas up to 1 - 2 km above the Fish River Bridge are excluded, then this diversity is appreciably lowered.

An interesting note is that several species of vertebrates considered threatened or endangered by the U.S. Fish and Wildlife Service were observed in Weeks Bay or surroundings. Included in our findings are the Osprey, the Brown Pelican, Wilson's Plover, the American Alligator and the Alabama Red-Bellied Turtle (declared endangered July 16, 1987). Others that are considered uncommon or threatened in Alabama occur (Mount, 1986). These offer possibilities for future educational and research projects.

We captured a large female Red-Bellied Turtle in a hoop net during Dr. Dobie's visit. The turtle was 38cm carapace length and greater than 15 years old. Several other probable individuals of this species were visually sighted in Fish River about 1 km north of the Fish River Bridge. This species has historically been reported as present in the Fish River (Mount, 1975). Since this animal is endemic only to the Mobile Delta region, generally north of the Mobile Causeway (Mount, 1975), the confirmations of a still-viable population here is of potential significance to the Reserve. Future work will evaluate the status of this population.

CONCLUSION AND RECOMMENDATIONS

This study has investigated the population status of various vertebrate species in the Weeks Bay National Estuarine Reserve and has provided a working

knowledge and evaluation of the "environmental condition" of the Reserve. First, this study has characterized the major habitat types and its animal associates within the Reserve and surrounding areas. Small areas of diverse habitat types are found, ranging from hardwood swamp forest to sand dune habitat. These account for a species list of vertebrates which collectively have a wide array of habitat requirements. The dominating habitat can best be described, based on the animal associates found, as a brackish estuary with occasionally strong freshwater influx, bordered by a mixed pine/hardwood lowland forest. The types, distributions, and abundances of the non-fish vertebrates observed and quantified clearly indicate that saltwater influence is not the dominant, overriding environmental factor determining vertebrate distrubiton in this estuary. Second, this study has demonstrated no obvious or major detrimental ecological impacts of recent origin on the estuary. Most of the animal types and population levels approximate what would be nominally expected from the particular habitat type(s) characterized, and are more reflective of responses to natural environmental factors, rather than pollution or severe habitat alteration. Some habitat alterations have occurred around dwellings and a small section of forest that has been cleared in recent years, but major tracts are relatively undisturbed. No existing water quality problems were revealed from investigating the types and abundances of animals. The lack of submerged vegetation may suggest the possibility of some water quality problems, but we have no historical knowledge of previous abundance.

The results from this study have several present and potential future implications or benefits:

1) The present knowledge of species occurrences, abundances, and diversity can be used in the future to assess potential long-term ecological changes due to pollution or habitat disturbance. This may

be particularly significant in view of increasing residential and urban development on the river systems feeding the Reserve.

2) Our findings have improved the knowledge of what species occur within the Reserve and surrounding areas, and have provided additional information on abundances and distributions. The lowland forests/coastal marsh habitats are the most poorly investigated habitats in Alabama, with many gaps in our knowledge of vertebrate distributions, abundances, and habitat associations. Our data has contributed to this limited pool of information.

3) The study has provided preliminary information on the occurrence of several uncommon, threatened or endangered species within the Reserve and adjacent areas. This offers possibilities for future educational programs and research projects. The authors are currently using the confirmation of a population of Alabama Red-Bellied Turtles provided by the present study to assess the population level of this species in Fish River and the upper Weeks Bay Reserve (NOAA Grant #NA87AA-D-CZ015).

4) Our results have suggested areas for future research, primarily by improving the knowledge of what organisms are present.

5) The study has provided important preliminary background information which will be expanded upon to assist future educational programs to enhance public awareness of the Weeks Bay estuary and estuaries in general. The authors have been awarded a current Sanctuaries Program award (NOAA Grant # NA87AA-D-CZ015) to expand the vertebrate surveys begun during the current reporting projects. The ultimate goal is to provide printed guides/checklists of those organisms found and where they can be found within the Reserve. This and other natural history printed material will be incorporated into future educational plans and programs now being designed for the Reserve.

Recommendations for the future include:

1) a continuation of vertebrate surveys in order to improve our knowledge of species occurrence;
2) a monitoring of the population status of the Alabama Red-Bellied Turtle within the Reserve area;
3) a reevaluation of species numbers and diversity within the next decade for assessment of potential long-term changes in the estuary; and
4) an investigation to determine whether the lack of submerged vegetation is natural or man-induced.

Table 1. Birds Recorded on Four 300-meter Shoreline Transects Established in the Weeks Bay National Estuarine Reserve. Each transect was surveyed by boat for twenty minutes. Each figure given represents the sum total number of birds recorded for all four transects during a day. The number of days in which quantitative surveys were made is given in parentheses following the season. ¶ = recorded only by call during a day; (?) = probable identification by sight or call. The order of listing follows Peterson (1980). Because of their frequent use in birds, only common names are listed. Winter = December-February; spring = March-May; summer = June-August; fall = September-November.

	Winter (3)	Spring (3)	Summer (5)	Fall (3)
Common Loon	1			
Horned Grebe	1, 8	1		
Pied-billed Grebe	2, 2	1		1
Brown Pelican	2, 7, 2	5		5
Double-crested Cormorant	4	4		
Great Blue Heron	1, 4, 2	1, 1, ¶	1, 6, 1	3, 4, 4
Green Heron		2	4, 6, 5, 5	¶
Little Blue Heron			1, 3, 2	1, 1
Great Egret	1, 4		1	3
Blue-winged Teal	3, 7			
Hooded Merganser	5			
Common Merganser	4			
Red-breasted Merganser	12			
Turkey Vulture	1, 5, 1	1	1, 4	1, 3
Black Vulture			2	
Red-Tailed Hawk	1	2	1, ¶	1, 1, 1
Northern Harrier	1			1
Osprey	1	1	1	
American Kestrel				1
Common Bobwhite			¶	

	Winter (3)	Spring (3)	Summer (5)	Fall (3)
Wild Turkey	¶ (?)			
King Rail		¶		
Clapper Rail				1, ¶
American Coot				7
Wilson's Plover	1			
Herring Gull	2		1	
Ring-billed Gull	3			
Laughing Gull	1, 1, 2	6, 2, ¶	12, ¶, ¶	2, 1, 53
Forster's Tern		30		5, 7
Common Tern	1	4, ¶	3, ¶	2
Little Tern	1	6		1
Royal Tern		1	2	1
Mourning Dove			¶	
Yellow-billed Cuckoo			¶	
Chimney Swift			1	
Belted Kingfisher	4, 3, ¶	1	1, 3, ¶	3, 9, 3
Common Flicker	2	1, 2, ¶		
Pileated Woodpecker	¶	1	1, 1, ¶	
Red-bellied Woodpecker	2, ¶		¶, ¶	2, ¶
Red-headed Woodpecker	¶		4, 2, 2, 2, 4	2, ¶
Hairy Woodpecker	1	1		1
Eastern Kingbird			1, 2, 2	1, 1
Great Crested Flycatcher		1	1, 2, ¶	
Scissor-tailed Flycatcher		1		
Barn Swallow		1	3	30, ¶
Purple Martin	1	34, 5, ¶	9, 43, 8, 16, ¶	

	Winter (3)	Spring (3)	Summer (5)	Fall (3)
Blue Jay	¶	¶, ¶	2, 2, 1, 2, ¶	¶
Fish Crow		3, 3, 5	6, 2, 7, 2, 3	¶
Carolina Chickadee	¶	¶	¶	
Tufted Titmouse			¶	
White-breasted Nuthatch				1, 2
Carolina Wren	¶		1, ¶	1
Mockingbird		¶, ¶	1, ¶	
Brown Thrasher		¶	1	2
American Robin	1			
Ruby-crowned Kinglet	7 (?), 1, ¶			
Red-eyed Vireo			¶	
Kentucky Warbler			¶	
Yellow-rumped (myrtle) Warbler	39, 8, ¶	¶		¶
Pine Warbler	3, 12, ¶	¶, ¶	¶	1, ¶
Common Yellowthroat			¶	
Red-winged Blackbird	68	1, 5, 3	6, 6, 6, 1, ¶	20, ¶
Boat-tailed Grackle		1, 9	1	
Common Grackle	1	1, 3	14, 18, 2, ¶	
Summer Tanager			¶	
Cardinal	¶	1, ¶, ¶	¶	1, ¶
American Goldfinch				1
Rufous-sided Towhee			1, 1, ¶	
White-throated Sparrow	¶			
Swamp Sparrow	¶ (?)	¶ (?)		

Table 2. Birds Recorded on Two 300-meter Transects Established at the Salt Marsh/Wooded Shoreline Areas of Fowl River, Mobile County, Alabama. Each transect was surveyed by boat for twenty minutes. Each figure given represents the sum total of birds recorded for both transects during a day. Surveys were conducted during six days. ¶ = recorded only by call during a day. The order of listing follows Peterson (1980). Because of frequent use in birds, only common names are listed.

Brown Pelican	5, 3
Double-coated Cormorant	4
Great Blue Heron	2, 1, 3, 1, 1, 1
Little Blue Heron	2, 2, 2
Great Egret	1, 1, 1
Snowy Egret	1, 6, 3, 1
Cattle Egret	21, 5, 12
Louisiana Heron	4, 2, 1
Blue-winged Teal	6
Scaup	10
Black Vulture	2, 2
Osprey	1, 1, 1
Clapper Rail	3, ¶, ¶
American Coot	6
Sanderling	13
Herring Gull	1, 2, 1
Laughing Gull	5, 21, 25, 1, ¶, ¶
Common Tern	1, 7, ¶, ¶
Royal Tern	2, 3, 5, 11
Little Tern	3, 1, 10, 6, 6, ¶
Forster's Tern	6
Sandwich Tern	10, 6

Gull-billed Tern	1
Black Skimmer	2
Barn Swallow	5
Purple Martin	7, 5, ¶
Chimney Swift	2, ¶
Great Crested Flycatcher	1, ¶
Eastern Kingbird	2, ¶
Belted Kingfisher	2
Blue Jay	¶
Fish Crow	1, 5, ¶
Yellow-throated Warbler	¶
Pine Warbler	¶
Red-winged Blackbird	4, 2, 1, ¶
Cardinal	¶

Table 3. Reptiles and Amphibians Observed in the Weeks Bay National Estuarine Reserve and Immediate Surrounding Areas During 1986. * = identified by sight or capture during a trip; o = identified by sign or call only during a trip; ? = unconfirmed sighting or sign. The total number of symbols represents the total number of trips in which the species was sighted or sign was observed. The order of listing follows Conant (1975).

American Alligator (Alligator mississippiensis)	* * o
Gulf Coast Box Turtle (Terrapene carolina major)	*
Mississippi Diamondback Terrapin (Malaclemys terrapin pileata)	*
Yellow-Bellied Slider (Chrysemys scripta scripta)	* * * *
River Cooter (Chrysemys concinna)	* * * * * *
Florida Cooter (Chrysemys floridana)	* * * *
Alabama Red-Bellied Turtle (Chrysemys alabamensis)	* ? ?
Atlantic Loggerhead Turtle (Caretta caretta)	?
Florida Softshell (Trionyx ferox)	*
Green Anole (Anolis carolinensis)	* * * * *
Six-Lined Racerunner (Cnemidophorus sexlineatus)	* *
Ground Skink (Scincella lateralis)	* * * *
Five-Lined Skink (Eumeces fasciatus)	* * * *
Broad-Headed Skink (Eumeces laticeps)	* ?
Banded Water Snake (Nerodia fasciata fasciata)	* *
Yellow-Bellied Water Snake (Nerodia erythrogaster flavigaster)	o
Eastern Ribbon Snake (Thamnophis sauritus sauritus)	*
Black Racer (Coluber constrictor)	o
Rough Green Snake (Opheodrys aestivus)	*
Scarlet Kingsnake (Lampropeltis triangulum elapsoides)	*
Cottonmouth (Agkistrodon piscivorus)	* * ?
Eastern Diamondback Rattlesnake (Crotalus adamanteus)	?

Two-Toed Amphiuma (Amphiuma means)	?
Southern Toad (Bufo terrestris)	* *
Southern Cricket Frog (Acris gryllus)	* * * * * o
Spring Peeper (Hyla crucifer)	* (juv.) o o
Green Treefrog (Hyla cinerea)	o o
Pine Woods Treefrog (Hyla femoralis)	o o o
Squirrel Treefrog (Hyla squirella)	* o
Southern Chorus Frog (Pseudacris nigrita)	* (juv.) o
Bullfrog (Rana catesbeiana)	* *
Bronze Frog (Rana clamitans clamitans)	* (juv.) o
Southern Leopard Frog (Rana utricularia)	* * * * *

Table 4. Mammals Observed in the Weeks Bay National Estuarine Reserve and Immediate Surrounding Areas During 1986. * = identified by sight or capture during a trip; o = identified by sign only during a trip. The total number of symbols represents the total number of trips in which the species was sighted or sign was observed. The order of listing follows Burt and Grossenheider (1964).

Opossum (*Didelphis marsupialis*)	* o
Eastern Mole (*Scalopus aquaticus*)	o o o
Raccoon (*Procyon lotor*)	* * * o o o o o o o o o o o o o o
River Otter (*Lutra canadensis*)	* *
Bobcat (*Lynx rufus*)	o o o o
Eastern Gray Squirrel (*Sciurus carolinensis*)	* o
Cotton Mouse (*Peromyscus gossypinus*)	o
Rice Rat (*Oryzomys palustris*)	*
Hispid Cotton Rat (*Sigmodon hispidus*)	*
Swamp Rabbit (*Sylvilagus aquaticus*)	* o o o o
Whitetail Deer (*Odocoileus virginianus*)	* o
Armadillo (*Dasypus novemcinctus*)	* o o o o
Atlantic Bottlenose Dolphin (*Tursiops truncatus*)	* *

Table 5. **Birds Recorded in the Weeks Bay National Estuarine Reserve and Immediate Surrounding Areas During 1986.** Trips per season are indicated by parentheses following season. * = identified by sight during a trip; o = identified by call or song only during a trip; (?) = probable identification by sight or call. The total number of symbols represents the total number of trips in which the species was recorded. Trips were designated as either single days or two consecutive days, depending upon the length and nature of activities. The order of listing follows Peterson (1980).

	Winter (4)	Spring (4)	Summer (5)	Fall (4)
Common Loon	*	*		
Horned Grebe	* * * *	*		
Pied-billed Grebe	* * *	*		* *
Red-necked Grebe	* (?)			
Brown Pelican	* * * *	* * *		* * *
White Pelican				*
Double-crested Cormorant	* * * *	* * *		* * *
Great Blue Heron	* * * *	* * * o	* * *	* * * *
Green Heron		* * o	* * * *	o
Little Blue Heron			* * *	* * *
Great Egret	* * * *	*	* *	* * *
Snowy Egret	* *			
Yellow-crowned Night Heron			*	
Mallard	*		* * (Dom.)	* *
Blue-winged Teal	* *			
Wood Duck	*	*	*	
Common Goldeneye	*			
Hooded Merganser	* *			
Common Merganser	*			
Red-breasted Merganser	* *	*		

	Winter (4)	Spring (4)	Summer (5)	Fall (4)
Turkey Vulture	* * * *	* * *	* *	* *
Black Vulture	*	* *	*	
Sharp-shinned Hawk	*			
Red-tailed Hawk	* *	* * o	* o	* * * *
Red-shouldered Hawk		*	*	
Broad-winged Hawk	*			
Northern Harrier	*			*
Osprey	* * *	* *	* *	
American Kestrel	*			*
Common Bobwhite			o	
Wild Turkey	o (?)			
King Rail		o	o	* o
Clapper Rail		o	o	* o
American Coot	*			*
Wilson's Plover	*			
Herring Gull	* * * *	* *	*	
Ring-billed Gull	*	*	*	
Laughing Gull	* * * *	* * * *	* * * * *	* * * *
Forster's Tern		* *	* * *	* * *
Common Tern	* * * o	* * * *	* * * * *	* * * *
Little Tern	* * *	* * * o	* * * * o	*
Royal Tern	* * * *	* * *	* * * *	* * * *
Rock Dove			*	
Mourning Dove	*	*	o o	
Yellow-billed Cuckoo			* o	
Chimney Swift			*	
Belted Kingfisher	* * * *	* *	* *	* * * *

	Winter (4)	Spring (4)	Summer (5)	Fall (4)
Common Flicker	*	* * o	*	o
Pileated Woodpecker	* o	* *	* * o	
Red-bellied Woodpecker	* o	* o	o	* * o
Red-headed Woodpecker	o	* o	* * * * *	* o
Yellow-bellied Sapsucker				*
Hairy Woodpecker	*	*		*
Eastern Kingbird			* * *	* *
Great Crested Flycatcher		* o	* * o	
Eastern Peewee		o		
Scissor-tailed Flycatcher		*		
Barn Swallow		* * * o	* *	* * o
Purple Martin	*	* * * o	* * * * o	
Blue Jay	* o	o	* * * * o	o
Fish Crow	* * *	* * * *	* * * * *	* * o
Carolina Chickadee	o	o	o	
Tufted Titmouse			o	
White-breasted Nuthatch				* *
Carolina Wren	* * o	*	* o	*
Marsh Wren				*
Catbird				o
Mockingbird	*	* * o	* o	*
Brown Thrasher		o	*	*
American Robin	* *	o		
Blue-grey Gnatcatcher		*		
Ruby-crowned Kinglet	* * o	*		
Cedar Waxwing		*		

	Winter (4)	Spring (4)	Summer (5)	Fall (4)
European Starling		*		
White-eyed Vireo		o		
Yellow-throated Vireo				*
Red-eyed Vireo		o	o	
Blue-winged Warbler				*
Kentucky Warbler			o (?)	
Prothonotary Warbler				*
Yellow-rumped (myrtle) Warbler	* * o	* o		* o
Yellow-throated Warbler		o		
Pine Warbler	* * o	* o	o	* o
Common Yellowthroat		o	o	
House Sparrow		*		
Red-winged Blackbird	*	* * * *	* * * * o	* * o
Boat-tailed Grackle		* *	*	
Common Grackle	*	* * *	* * * o	o
Brown-headed Cowbird		*		
Summer Tanager		o	o	
Cardinal	o o	* * o	* o	* o
American Goldfinch				*
Rufous-sided Towhee			* * o	
Field Sparrow	*			
White-crowned Sparrow				*
White-throated Sparrow	o			
Swamp Sparrow	* * o	o (?)		o (?)
Song Sparrow	* (?)			

Table 6. Salinities Recorded at the Weeks Bay National Estuarine Reserve During 1986-87. Salinities were taken by refractometer during each trip in at least two of the following locations: Fish River Bridge, the inlet mouth, Transect 1, and Transect 4 (see Fig. 1). The maximum and minimum values recorded during each trip are presented.

Date	Max.	Min.
4/29/86	5	3
5/27/86	10	8
6/4/86	10	10
6/5/86	10	10
6/24/86	8	8
7/15/86	12	10
8/23/86	16	16
9/9/86	15	15
10/10/86	26	10
10/17/86	15	4
11/11/86	15	12
12/16/86	9	8
1/13/87	15	8
2/13/87	3	1
3/20/87	0	0

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